ER-7249-1

SUPPLEMENT TO FINAL REPORT ER-7249 INTEGRAL LUBRICATION PUMP DEVELOPMENT

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CONTINUED DEVELOPMENT OF A HYPERGOLIC ELECTRICAL POWER SYSTEM

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NASA MANNED SPACECRAFT CENTER
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SUPPLEMENT TO FINAL REPORT
ER-7249

INTEGRAL LUBRICATION PUMP DEVELOPMENT

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1.0 INTRODUCTION

This report covers the design, fabrication, and testing of the integral lubrication pump and complies with the requirements of the amended contract NAS 9-6879.

2.0 PUMP DESIGN

The integral pump design utilized two positive displacement pump elements manufactured by W. H. Nichols Company. The model 8030 pump selected for use had a capacity of 0.30 cubic inches per inch of thickness per revolution. The design flows for the scavenge and supply pumps were 2.0 and 1.0 gpm, respectively. For these flow requirements, the necessary thicknesses for the pump elements were 0.500 inch for the scavenge pump and 0.250 inch for the supply pump. Pump component details are shown in the included TRW drawing 814099-15. The assembly procedure for the gear pump is shown in the Appendix. The pump housing incorporates the scavange and supply pump elements separated by a spacer.

Figure 1 shows schematically the speed reduction gearing system utilized to drive the pump shaft from the turboalternator shaft. The speed reduction is accomplished in two steps. The pinion which is attached to the turboalternator shaft has 14 teeth and drives the double gear shaft at 9830 rpm when the turboalternator shaft speed is 33,000 rpm. The double gear shaft has a pinion mating gear with 47 teeth and a pump drive gear with 15 teeth. The second speed reduction is accomplished by driving the pump shaft gear which has 46 teeth with the 15 tooth pump drive gear attached to the double gear shaft. The speed reduction realized is from 9830 to 3200 rpm.

The double gear shaft and pump shaft are both supported with a ball and roller bearing combination to allow for thermal differential expansion between the shafts and the housings. A turboalternator shaft was extended so that the drive pinion could be locked onto the shaft.

All gears were fabricated from heat treated nitrided 4140 steel. The gear housing was cast utilizing AMS 5333 steel. The pump housing was also made from a casting but the material used was Meehanite GA50. The pump shaft was machined from 4340 barstock.

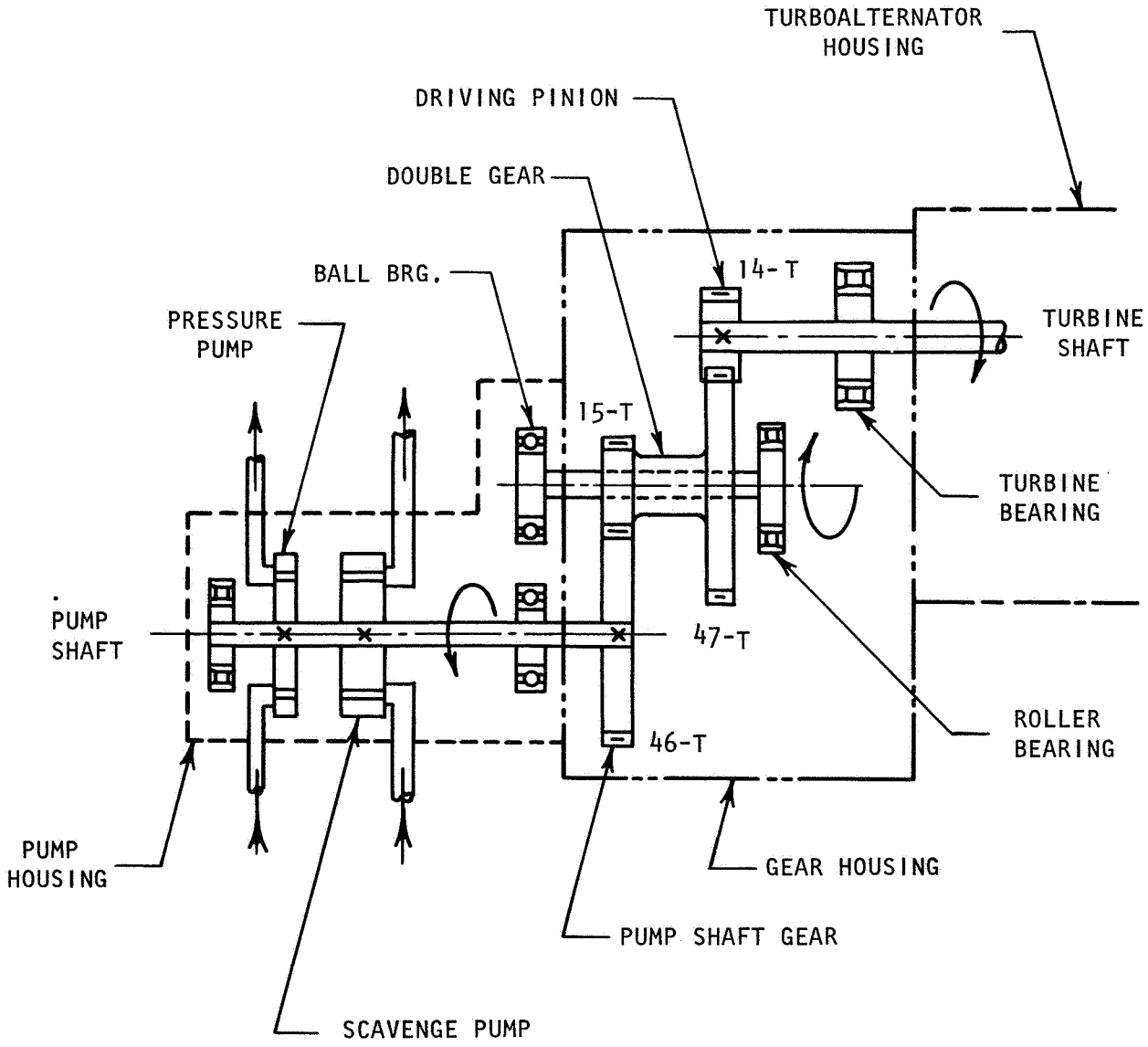


FIGURE 1 SCHEMATIC ARRANGEMENT

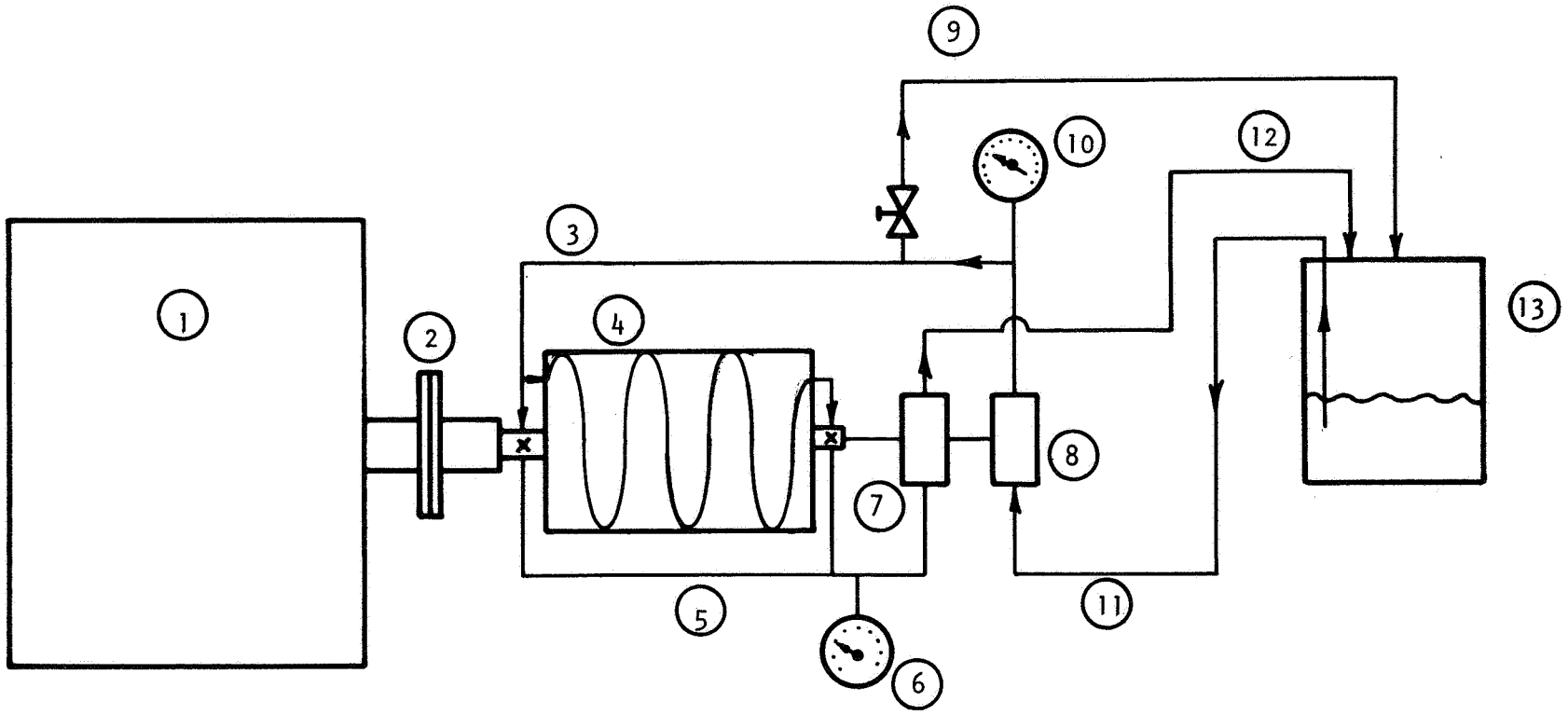
3.0 TEST DESCRIPTION

The purpose of the pump test was to demonstrate the feasibility of the integral lubrication pump design. The test was conducted at the TRW Cleveland facility. The test system schematic is shown in Figure 2. Although the final lubrication system design will incorporate an oil radiator for cooling, it was not employed for this test because elevated oil temperature testing was not conducted. The oil that was used for the test was PQ lubricant 6423 which complies with the specification MIL-L-23699. This oil has a slight amount of silicone to prevent foaming. Approximately two gallons of oil was placed into the oil reservoir. The inlet of the supply pump was connected to the oil reservoir by a 1/4 inch diameter flexible hose. A 1/4 inch diameter copper tubing section was installed between the supply pump discharge and the alternator oil inlet port. In addition, a pressure gage and a bleed line was also installed in this section in order to measure supply pump performance and also to provide flow control to the turboalternator. A common scavenge line (one inch diameter flex hose) was connected from the ball bearing and roller bearing cavities to the inlet of the scavenge pump. The scavenge pressure was measured on a vacuum gage which was mounted in the scavenge line. The scavenge pump discharge was fed back into the reservoir where the flow rate was measured by collecting the flow in a 1000 milliter beaker. The oil temperature was monitored downstream of the supply pump discharge. Thermocouples were used to measure the ball bearing and roller bearing temperatures. The turboalternator shaft speed did not exceed 18,000 rpm because of dynamometer limitations.

4.0 TEST RESULTS

The integral lubrication pump was in operation for approximately one hour at various speeds from 0-18,000 rpm. The oil temperature did not exceed 125°F.

The measured pump performance is shown in Figure 3. It was suspected that the scavenge pump performance was adversely affected by air leaks into the scavenge line. It was determined that the supply pump will begin pumping oil to the alternator at turboalternator shaft speeds of less than 1000 rpm. Thus oil could be supplied to the bearings after the first pulse of the gas generator during system startup. The test successfully demonstrated the design feasibility and verified the design parameters when the rated pump capacities were achieved.



1. DYNOMOMETER
2. TORQUE COUPLING
3. TURBOALTERNATOR OIL SUPPLY
4. TURBOALTERNATOR
5. BEARING SCAVENGE LINE
6. SCAVENGE LINE PRESSURE
7. SCAVENGE PUMP
8. SUPPLY PUMP
9. SUPPLY VENT LINE
10. SUPPLY PRESSURE
11. SUPPLY INLET LINE
12. SCAVENGE RETURN LINE
13. OIL RESERVOIR

FIGURE 2 TEST SYSTEM SCHEMATIC DIAGRAM

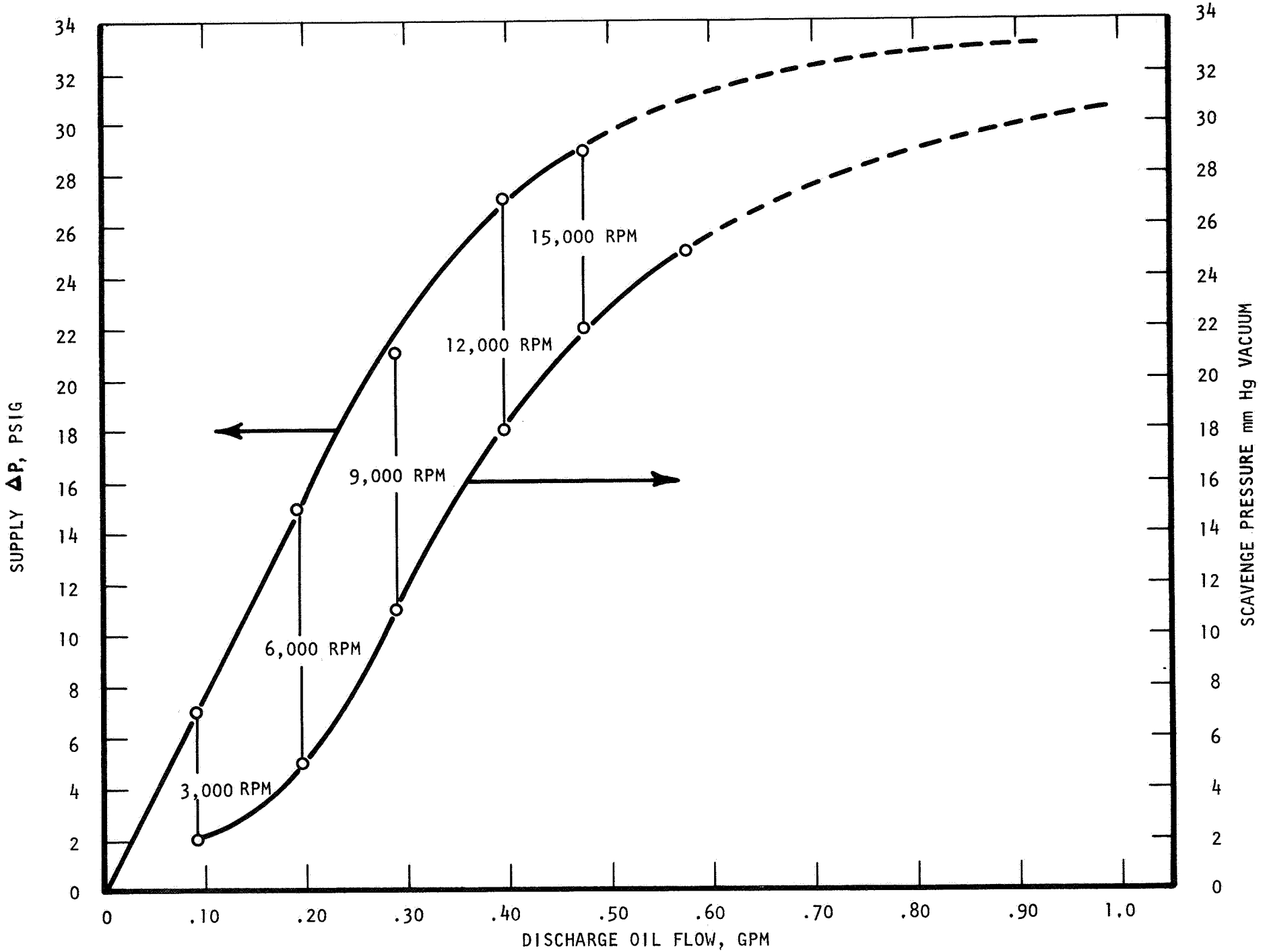


FIGURE 3 MEASURED PUMP PERFORMANCE

Figures 4 through 8 show the pump components after testing. Figure 4 shows the pump end cap which contains the pump shaft roller bearing and the inlet and discharge lines to the supply pump. Figure 5 shows an end view of the pump shaft and the scavenge pump elements assembled in the pump housing. The turboalternator shaft and gear housing are shown in Figure 6 with the pump housing removed. Figure 7 shows the pump housing with the end cap and gear housing removed. However, note the pump shaft and gear assemblies bolted in position. Figure 8 shows an exploded view of the pump shaft assembly, the pump housing, and the intermediate shaft assembly with the double gears.

5.0 RECOMMENDATIONS

Although, the pump test was successful, a redesign effort should be directed at weight reduction. Also, additional testing should be done utilizing a turboalternator test facility with the system rated speed capability. Also of interest is the pump performance at various lubricant temperatures.

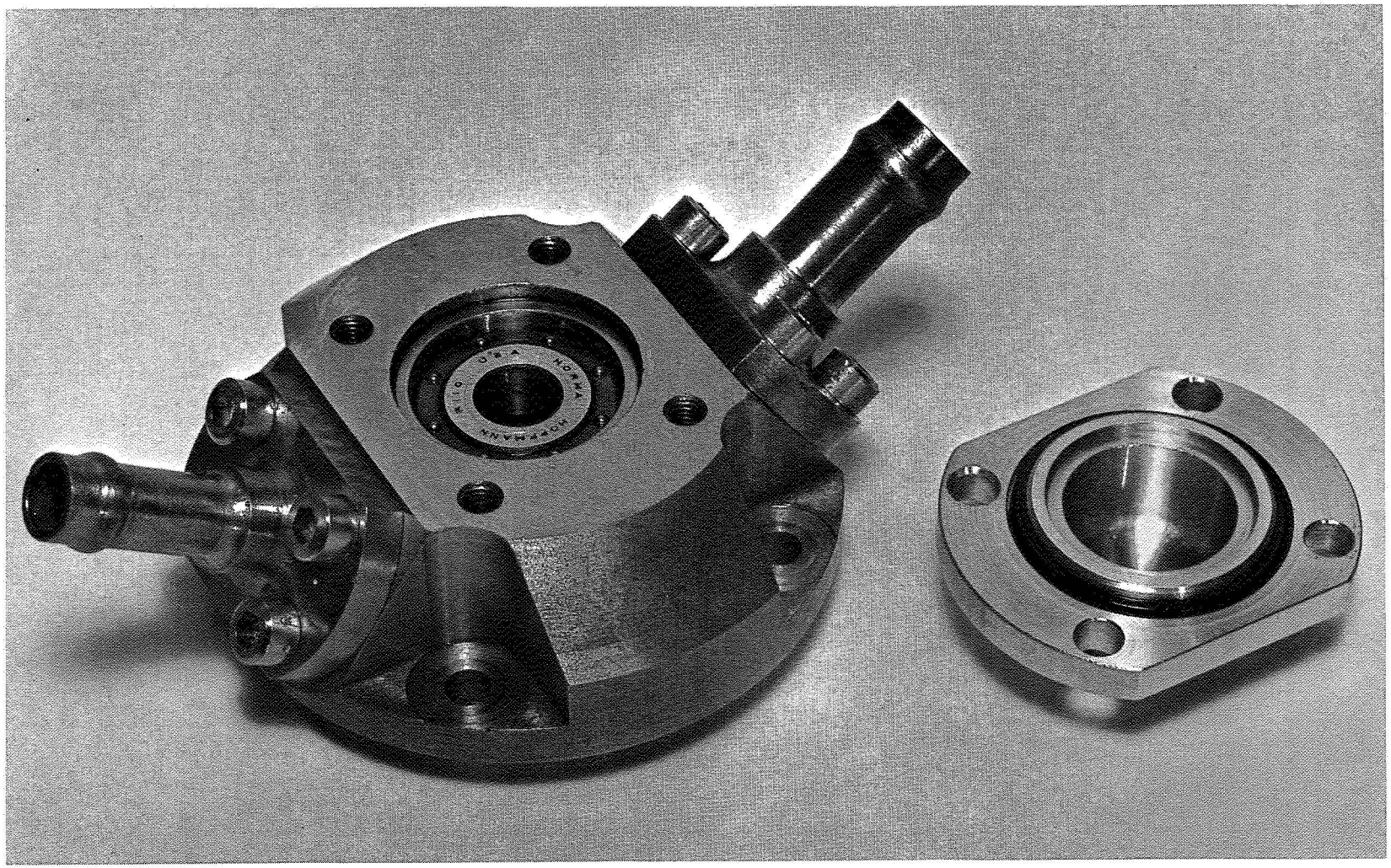


Figure 4. Pump End Cap

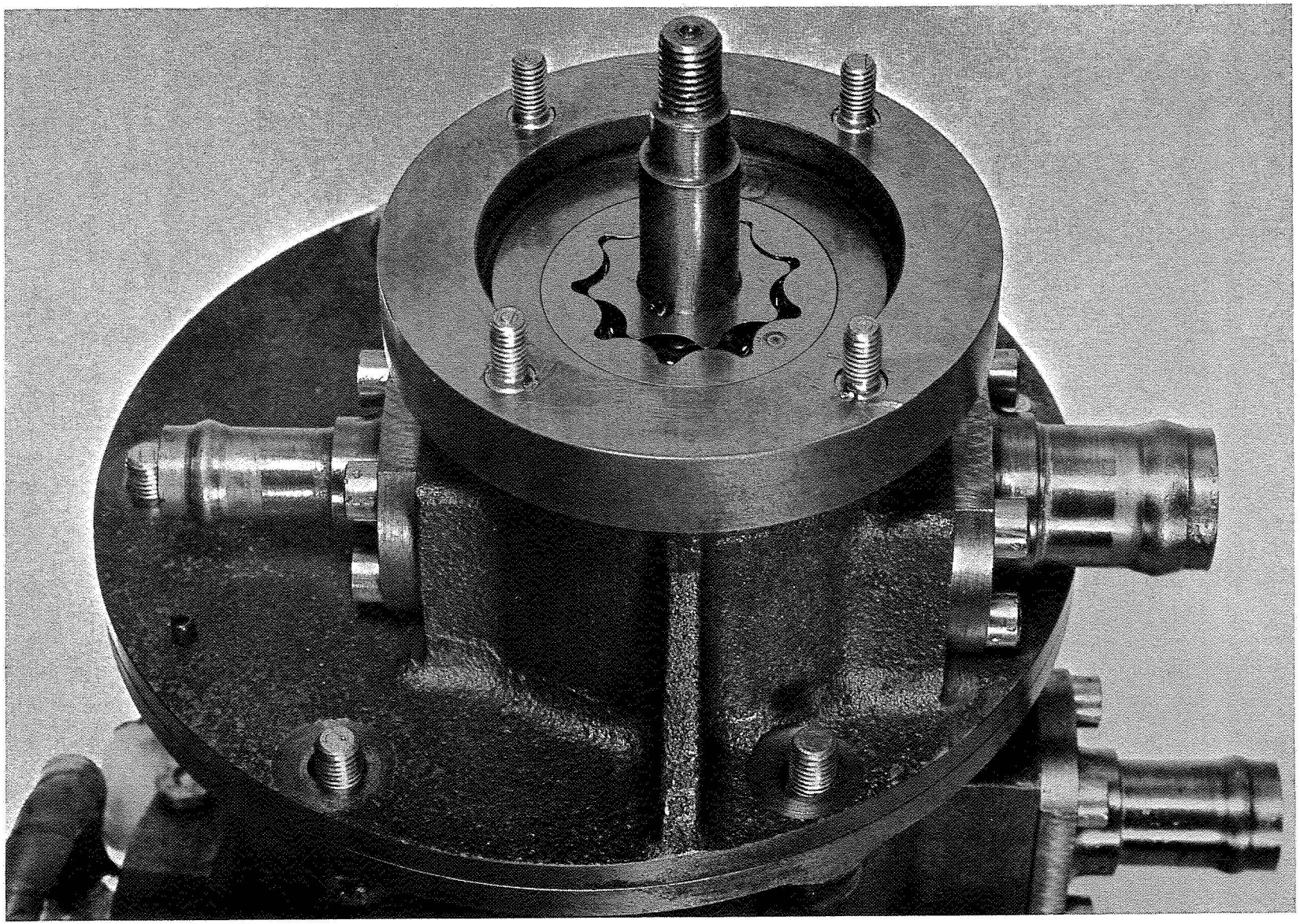


Figure 5. End View of Pump Shaft

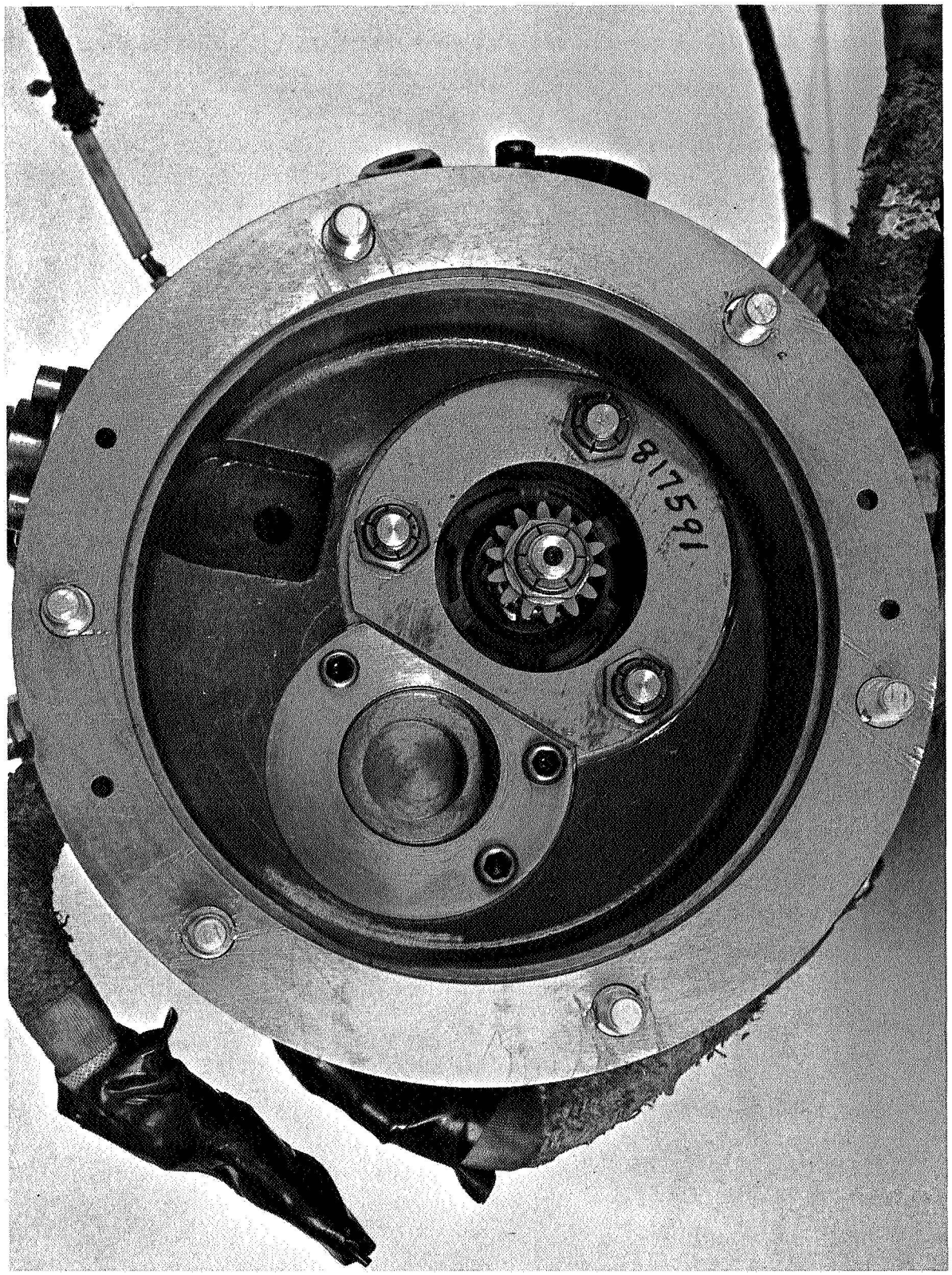


Figure 6. Turboalternator Shaft and Gear Housing

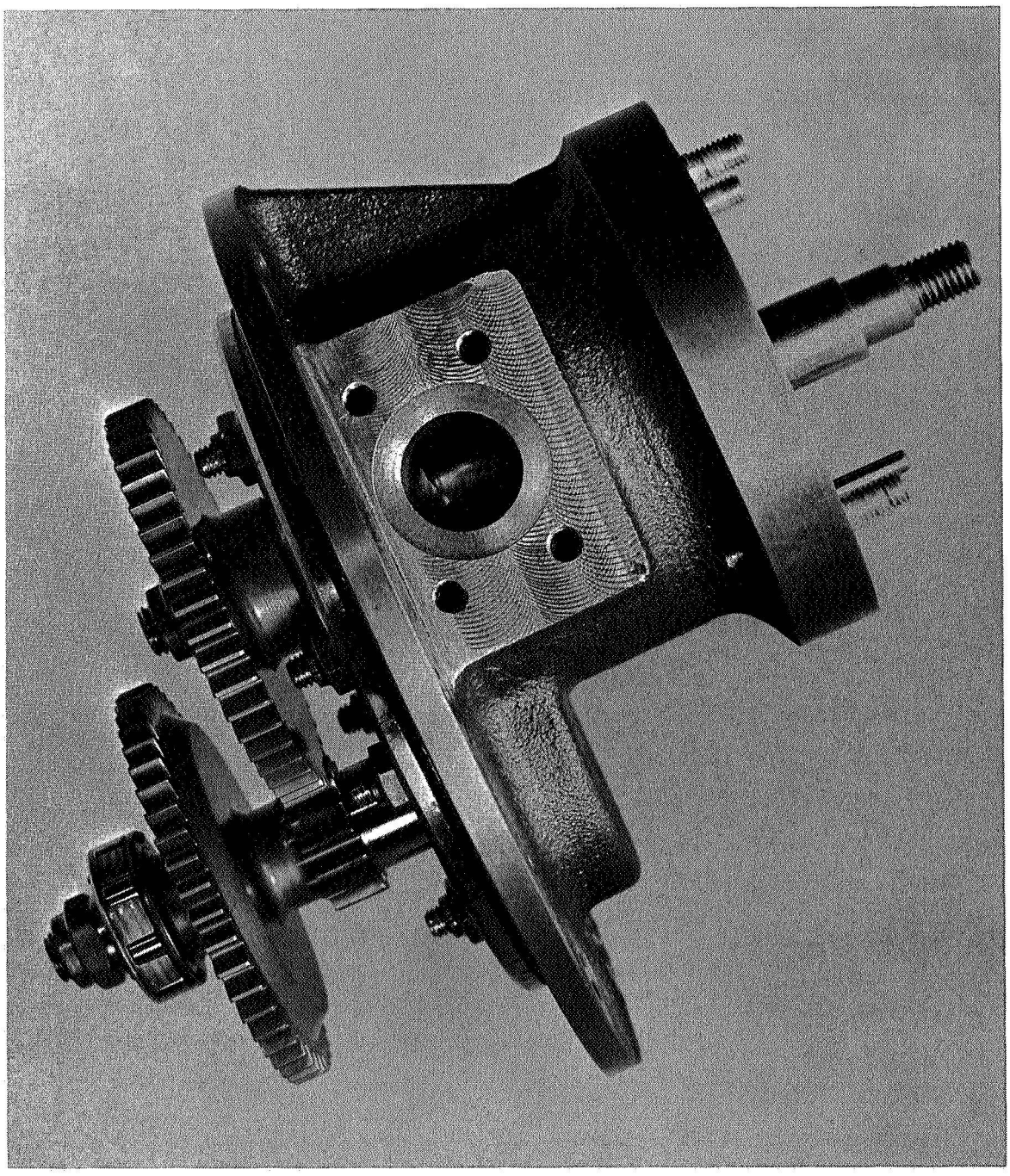


Figure 7. Pump Shaft and Gear Assemblies

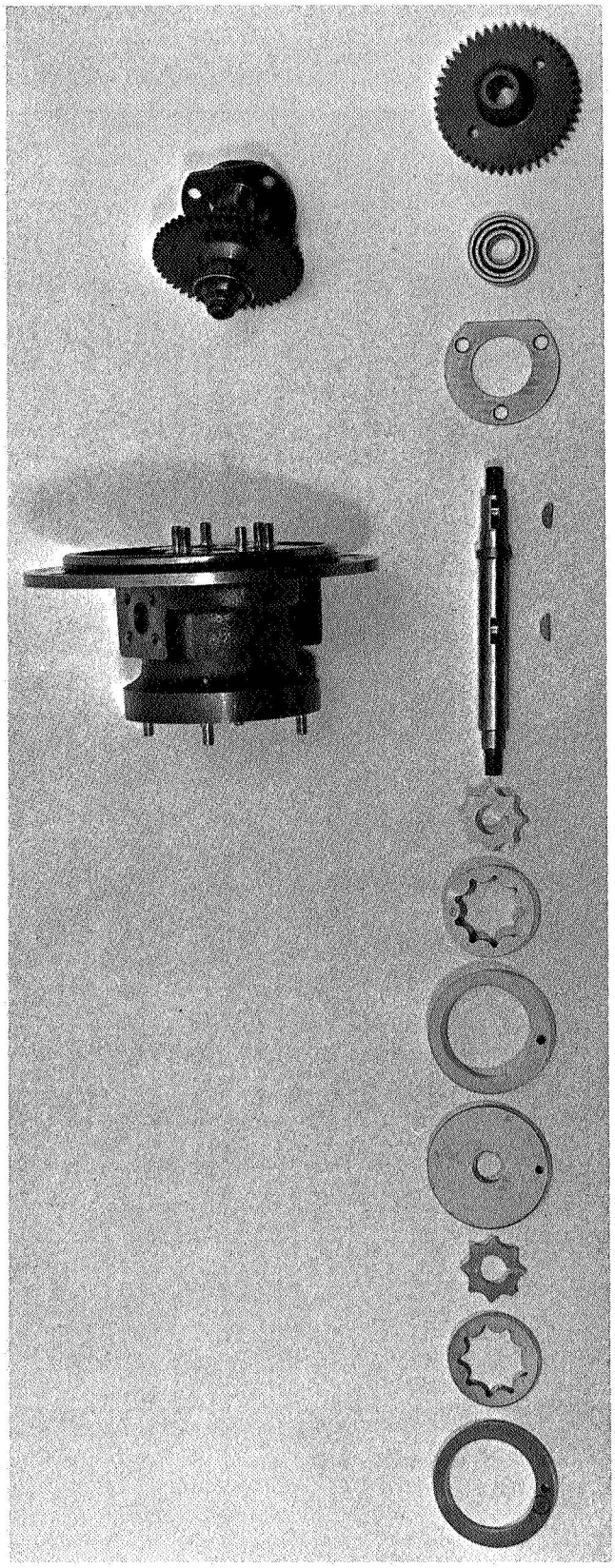


Figure 8. Exploded View

APPENDIX

ASSEMBLY OF GEAR PUMP

P/N 814099-15

Note: Use light machine oil on all bearings, gears, and machined parts during assembly.

Use Parker "O" ring lubricant on all "O" rings during assembly.

1. Assemble 3 studs (817611) to pump end of gear housing (817612).
2. Assemble 2 press bolts (817616) to pump end of gear housing (817612).
3. Assemble 5 studs (817586) to pump end of gear housing (817612).
4. Assemble retainer, roller bearing (817591) into pump end of gear housing (817612) and secure in place with 3 self locking hex nuts (817605).
5. Install outer race of roller bearing (817583) into intermediate bore of gear housing (817612) and secure in place with bearing retainer plate (817590) and 2 self locking hex nuts (817607).
   Note: Bearing retainer plate (817590) will not be flush with mating surface.
6. Assemble the following pieces of the intermediate shaft assembly in the following order:
   a) Press ball bearing (817582) onto shaft.
   b) Place bearing retainer plate (817581) over the bearing.
   c) Place gear spacer (817588) next to bearing.
   d) Press double gear (817593) onto shaft.
   e) Press inner race of roller bearing (817583) onto shaft.
   f) Place washer (817584) on shaft.
   g) Secure shaft assembly with self locking hex nut.
7. Assemble 4 studs (817585) to pump cap and pump housing (817615).
8. Assemble 6 studs (817585) to alternator end of pump housing (817615).
9. Install dowel pin (817603) and outer race of roller bearing (817583) into pump cap (817596).
10. Install pump shaft (817597) into pump housing (817615).

11. Install scavenge pump driving element (817613) into pump cavity of pump housing (817615).

12. Install drive pin (817603) into pump shaft (817597). CAUTION: Do not push too far.

13. Install ball bearing (817582) on pump shaft and in the housing bore.

14. Assemble bearing retainer (817581) into pump housing and secure with 3 self locking hex nuts (817607).

15. Install pump drive gear (817594) with woodruff key (817608-2) and a 5/16-24 plain nut onto the pump shaft. This is a temporary assembly at this time.

16. Install outer element of scavenger pump (817613) into pump cavity of pump housing (817615). Line up threaded hole with narrow pump slot in pump housing.

17. Install driven pump element (817613) into pump cavity of pump housing (817615). CAUTION: Make sure dot faces up.

18. Install locating pin (817609) into scavenge pump (817613).

19. Install pump spacer (817610) into pump cavity.

20. Install outer element of pressure pump (817614) into pump cavity of pump housing (817615).

21. Install driven element of pressure pump (817614) into pump cavity.

22. Assemble pump cap (817596) to pump housing and install roller bearing (817583) into pump cap. Use "O" ring (810677-BSA) when assembling pump cap into pump housing.

23. Install 4 self locking 10-32 hex nuts to secure the pump cap in place.
Note: There will be a space of approximately .003 inch between pump cap and pump housing when nuts are torqued properly.

24. Install intermediate shaft assembly into pump housing (817615). Secure bearing retainer in place with 3 self locking 10-32 hex nuts (817706).

25. Install flat washer (817584) and hex nut (817606) on pump shaft. Hold gear with spanner while torquing nut.

26. Install bearing cap retainer (817589) with "O" ring (810677-BSA). Secure in place with 4 hex socket cap screws (808624-278KA).

27. Check for end play of pump shaft.

28. Check to make sure the pump housing (817615) and gear housing (817612) fit together and that there is no interference between the two assembled housings. This is merely a check of the two housings at this time.

29. Install gear housing (817612) onto the back of alternator housing (816598) using "O" rings (810677-EAA) and (808605). Also install the two small tubes (816654) at this time. CAUTION: Make sure the scavenge port of the two housings line up with each other. Alignment of the two small tubes with the small "O" rings should be done with care. Bolt together with 9 high temperature hex head bolts.

30. Install magnetic pickup (816787) on turbine shaft. (Note: Left hand thread) Lock in place with locknut (815184) and torque to 37 to 42 ft-lb.

31. Install shoulder washer (817602), pinion (817592), and woodruff key (817608-1) on turbine shaft and lock in place with washer (817584) and self locking nut (817606).

32. Assemble pump housing (817615) with "O" ring (810677EAA) into the gear housing (817612). Engage the gears carefully. Lock in place with 5 hex head cap screws (MS 35308-305) and dowel pin (808627-17A).

33. Install connectors (817598-1) and 2 pieces (817598-2) with "O" ring (808650-AMA) to the proper pump ports. Secure in place with hex socket cap screws (808624-223 KA).

34. Install scavenge inlet connector (817604) and housing outlet connector (817598-3) with "O" rings (808650-ASA) to the proper pump ports. Secure in place with hex socket cap screws (808624-223KA).

35. Install 2 oil jets (816619) into the gear housing. Be careful not to damage the "O" rings. Secure with No. 8-32 x 3/8 long screws in each jet.

(Errata Sheet No. 1)
ER-7249

1.0 INTRODUCTION

This report describes the work performed during the second phase in the development of a hypergolic turboalternator power system. Phase I of this work was performed previously under NASA Contract NAS 9-4820 and was continued as Phase II under Contract NAS 9-6879. The effort during the Phase II program was directed toward finalizing and verifying the design of a flight-type system for use as a complimentary Lunar Module (LM) Electrical Power System to extend LM stay time. The work described in this report includes the results of component and flight system development and two 100 hour system endurance tests. The period of contractual performance covered approximately a 10 month time span from April 1967 through January 1968.